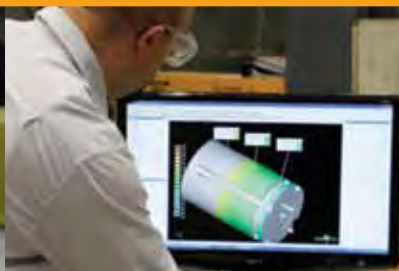
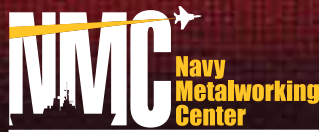


2011 Annual Report



# Advanced Metalworking Solutions

For Naval Systems That  
Go In Harm's Way



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On September 23, 2011, Admiral Jonathan Greenert became the 30th Chief of Naval Operations and promptly shared the three tenets that will guide the Navy under his leadership – Warfighting First, Operate Forward, and Be Ready. Guiding Admiral Greenert’s tenets is his vision, which includes innovation through new technologies and operating concepts as well as sustaining our fleet capability through effective maintenance, timely modernization, and sustained production of proven ships and aircraft.

The work of the Navy Metalworking Center (NMC) reflects that vision. NMC and its government and industry partners develop and transition advanced manufacturing solutions to improve the U.S. Navy fleet’s affordability and mission capability. This report highlights the broad applications for the technology that NMC advances for the fleet, especially the platforms in the Office of Naval Research’s focused investment strategy – Virginia Class Submarines (VCS), CVN 78, DDG 1000/51, and the Littoral Combat Ship (LCS).

# MESSAGES FROM THE DIRECTORS

In his 2011 guidance, Chief of Naval Operations Admiral Gary Roughead said that the demand for U.S. Navy forces is increasing. As you would imagine, it's no easy task to add naval capabilities in light of current budget challenges. In Admiral Roughead's words, "There is no option; the Navy will work more efficiently in our resource-constrained environment." The Navy Metalworking Center (NMC) plays an important role in achieving that efficiency.

NMC develops advanced metalworking and manufacturing technologies, materials, and related processes that improve the affordability of Navy weapon systems. We are proud of our achievements to meet the Navy's needs through a variety of technologies, and we are honored by the recognition we've received from outside organizations. Most recently, the Department of Defense Joint Defense Manufacturing Technology Program gave NMC the 2010 Defense Manufacturing Technology Achievement Award for a project that developed a mechanized tool that shaves excess weld reinforcement faster and safer than the current hand-grinding method.

While earning recognition like this is gratifying, most engineers will tell you the real reward is seeing their work implemented in a real-world setting. The weld shaver system project illustrates NMC's approach to achieving successful implementation. It meets the Navy's need for improved affordability, it has broad application to the Navy and other services, and through our partnership approach, it achieved buy-in from the shipyard early in the process, which helped ensure its likelihood of implementation.

While we find satisfaction when our work is used on Navy weapon systems, that's usually not the end of the story. For example, we modified the successful weld shaver system to perform back gouging, and that tool is now being used in the construction of DDG 1000 and saving the Navy more than \$1 million on that platform alone. The bottom line is that we will continue to seek creative yet practical metalworking solutions that can be implemented on Naval systems that go in harm's way.

*Daniel L. Winterscheidt*

Daniel L. Winterscheidt, Ph.D.  
Program Director, Navy Metalworking Center

The Office of Naval Research provides technology solutions that preserve our national security by making the acquisition and maintenance of Navy and Marine Corps weapon systems more affordable. Paramount to the work of the Navy ManTech Centers of Excellence is the ability to transition innovative manufacturing technologies into real-world applications for the U.S. industrial base. In particular, Navy ManTech focuses its resources on the affordability goals of the Navy's Virginia Class Submarine, Littoral Combat Ship, DDG 51, and CVN 78, and the DoD's Joint Strike Fighter.



*Navy Metalworking Center Program Director Dan Winterscheidt (left)  
and Office of Naval Research Manufacturing Technology Program  
Director John Carney (right).*

The Navy Metalworking Center (NMC) has a strong record of leading projects that apply advanced technology to Navy weapon system manufacturing in order to cut costs, and ultimately, add capability to our Naval forces. To illustrate, this report contains details about NMC's current efforts to improve the performance, cost, and weight of uptakes on LCS. You will also read about NMC's successes in creating prototype tools for various applications, including a brazing system that will solve a variety of issues associated with the current manual method used in ship construction and improved large diameter pipe preparation that will save considerable cost in VCS construction.

Over the past few years, Navy ManTech has had a significant impact on affordability for the key platforms mentioned above. With the ongoing federal budget cuts, ensuring that we focus on projects that achieve implementation has never been more vital. I am confident that NMC will continue its successful application of advanced metalworking and manufacturing technologies that reduce costs, improve the fabrication of Navy weapon systems, and strengthen the U.S. industrial base.

*John U. Carney*

John U. Carney  
Director, Manufacturing Technology Program  
Office of Naval Research





# METALWORKING TECHNOLOGIES

*NMC's activities can be categorized into several manufacturing areas, including metalworking technologies; advanced metallic materials; design for manufacturability; joining technologies; shipyard processes; and coatings removal and application. NMC's recent metalworking technology work involves the diverse efforts of improving cryostat fabrication and developing casting solutions for the LCS waterjet inlet tunnel.*



*An NMC project used advanced techniques to design and manufacture the casting mold for the Freedom-class LCS waterjet entry edge. The cast component will save significant labor hours, improving the shipyard's ability to produce multiple ships.  
MMC photo*

NMC developed a casting solution for the Littoral Combat Ship (LCS) that saved considerable labor hours during ship construction as well as reduced weight, improved performance and decreased production time. During production of the first LCS hull at Marinette Marine Corporation (MMC), the leading edge of the waterjet inlet tunnel (WJIT) was made by welding 13 formed steel plates into the ship hull. Due to the production challenges of correctly positioning each plate while accounting for welding distortion, installation of the WJIT entry edge became costly and required significantly more production time than expected. The casting solution created in this project reduced the production time and cost for future LCS hulls and improved the accuracy of the complex curvature required of the entry edge. After evaluating several potential production methods, the team agreed that the best option was to cast the component in three separate segments. To ensure timely integration of the cast solution, molds were designed using casting simulation, which assured that porosity, distortion, and cracking were minimized or eliminated from the finished castings. Sand molds were printed by team member ProMetal® using direct digital manufacturing. Custom-fitted chills were produced from the computer solid model. All mold segments were printed in two



days, shipped to the foundry, assembled and were ready for pouring within two weeks from the date the mold design was finalized in the casting simulation. This approach allowed the team to produce a superior quality casting, while maintaining a tight schedule and at a cost significantly lower than traditional sand casting methods. The solution identified and demonstrated by this project is now MMC's preferred production

method for the four WJIT entry edges required per hull. The American Bureau of Shipping (ABS) certified the casting method for use on future LCS platforms. Beyond that application, sand mold printing technology—coupled with numerical simulation—offers opportunities for production of many other components. The Integrated Project Team (IPT) for this effort included NMC, the LCS Program Office, Lockheed Martin Mission Systems & Sensors (LM MS2), Bollinger Shipyards, ABS, Gibbs & Cox, and ProMetal.



*Initial testing has been completed to evaluate HTSDG cryostat performance using five-meter long prototypes. NASA, Kennedy Space Center photo*

The Navy intends to use High Temperature Superconducting Degaussing (HTSDG) coil systems on future Navy platforms. NMC is concluding its work to address cryostat configuration and manufacturing issues associated with fabricating long lengths of flexible, vacuum-jacketed cryostats that meet Navy shipboard performance requirements. The project included provisions to evaluate the reliability performance, as well as proofing of fabrication techniques. Cryostat

multilayer insulation systems devised on the project using a standardized cryogenic test facility have been validated on five-meter-long test samples. Technical tasking has identified and provided preliminary confirmation of a manufacturing process that will meet Navy HTSDG requirements. NMC worked with an IPT consisting of LCS Program Office, Naval Surface Warfare Center, Carderock Division (NSWCCD), Southwire Company, Oak Ridge National Laboratory, ASRC Aerospace, and NASA Kennedy Space Center to complete these efforts.



*NMC has developed solutions for the construction of LCS, a ship program initiated in 2002 to operate in littoral or close to shore environments, as well as open seas. Current NMC efforts are in the metalworking technologies and advanced metallic materials areas. Shown is the Pre-Commissioning Unit (PCU) Fort Worth (LCS 3). U.S. Navy photo courtesy of Marinette Marine Corporation*

# ADVANCED METALLIC MATERIALS

*NMC has a successful record of developing processing methods that enable the use of new or advanced materials in Navy shipbuilding to improve performance and/or cut costs. Current efforts involve titanium, high-strength steel, and other alternate materials.*



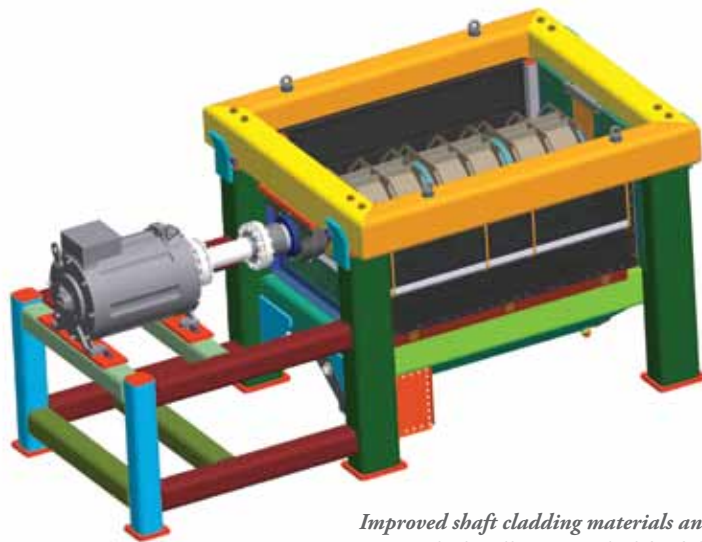
*A cost-effective manufacturing solution enabling the use of an alternate material in gas turbine exhaust uptakes will reduce weight and life-cycle costs on LCS. Gibbs & Cox photo*

NMC is investigating the use of an alternate material in a critical component on the LCS platform to address the need to reduce the structural weight. A potential area for achieving weight reduction is the high-temperature exhaust ducting for the gas turbine engines (uptakes). The uptakes are currently comprised of an INCONEL® Alloy 625 interior wall that is exposed to an exhaust temperature of 840°F, a layer of thermal insulation, and a stainless steel exterior that reaches a maximum temperature of 550°F. While using an alternate metal for the uptakes would be beneficial in terms of performance and potential life-cycle cost based on superior corrosion resistance, the material and fabrication costs can be high. This NMC project will employ high-speed, hot-wire gas metal arc welding (GMAW) and net-shape manufacturing approaches to reduce cost. Using the different material and a single-wall configuration in the uptakes are expected to result in a structural weight reduction, which may assist in faster ship speed and enhance the flexibility in changing out mission modules. In addition, GMAW is expected to decrease welding fabrication time. Once implemented, the proven corrosion resistance of the alternate metal should enable life-cycle cost savings as well. The updated uptake is expected to be fully implemented on LCS 5 and for subsequent LCS builds. The IPT includes LCS Program Office, LM MS2, Gibbs & Cox, Titanium Fabrication Corporation, MMC, NSWCCD, ABS, and NMC.





NMC developed processing parameters of a corrosion-resistant ferrous alloy that will save \$9.4 million over the remaining life of 70 in-service submarine hulls. The torpedo tube muzzle door operating linkage for the Los Angeles (SSN 688) and subsequent classes of Navy submarines include several critical components produced from K-Monel® (Ni-Cu-Al) forgings. The components do not function as needed in a corrosive seawater environment and must be replaced after eight years of service. This project sought to substitute the K-Monel forgings with a modified 15-5PH steel, which provides improved mechanical properties and corrosion resistance, avoiding the need to replace components during the submarine's lifetime. This project formulated critical forging and heat treating parameters that will result in material properties tailored for this specific application. 15-5PH linkage components are planned for implementation on the Los Angeles and Ohio class in-service submarines during the next planned retrofit cycle, which should commence in FY14. In addition to improved mechanical properties, replacing K-Monel with 15-5PH forgings will provide material and labor cost savings. This effort included input from the VCS and Strategic and Attack Submarines Program Office, NAVSEA 05Z45, NAVSEA 05P24, Naval Undersea Warfare Center, NSWCCD, Electric Boat (EB) and NMC.



*Improved shaft cladding materials and processes, which will increase the life of the main propulsion shafting system on VCS, are being validated on a test stand designed to replicate the system. NMC image*

NMC is analyzing different material combinations to increase the time between required replacements of the VCS main propulsion shaft. Extending the replacement periodicity will contribute to the possible elimination of one maintenance availability over the life of each VCS. The cost savings per shaft replacement have been estimated at \$4 million, which includes \$3 million in recurring material and labor costs associated with each VCS propulsion shaft replacement, and \$1 million associated with each shaft refurbishment at the vendor. The IPT will test current and potential alternative shaft journal materials manufactured using various processes on an intermediate-size test stand designed to replicate VCS main propulsion shafting systems. The recommended material combinations will be integrated into future VCS shaft designs for both original manufacture and refurbishment. EB will begin placing orders for this purchase in January 2013. Material recommendations from this project will be implemented within the Block IV procurement while the Navy concurrently conducts qualification testing using a full-size test stand. This NMC project includes contributions from the VCS Program Office, NAVSEA, EB, and the Institute for Manufacturing and Sustainment Technologies (iMAST).

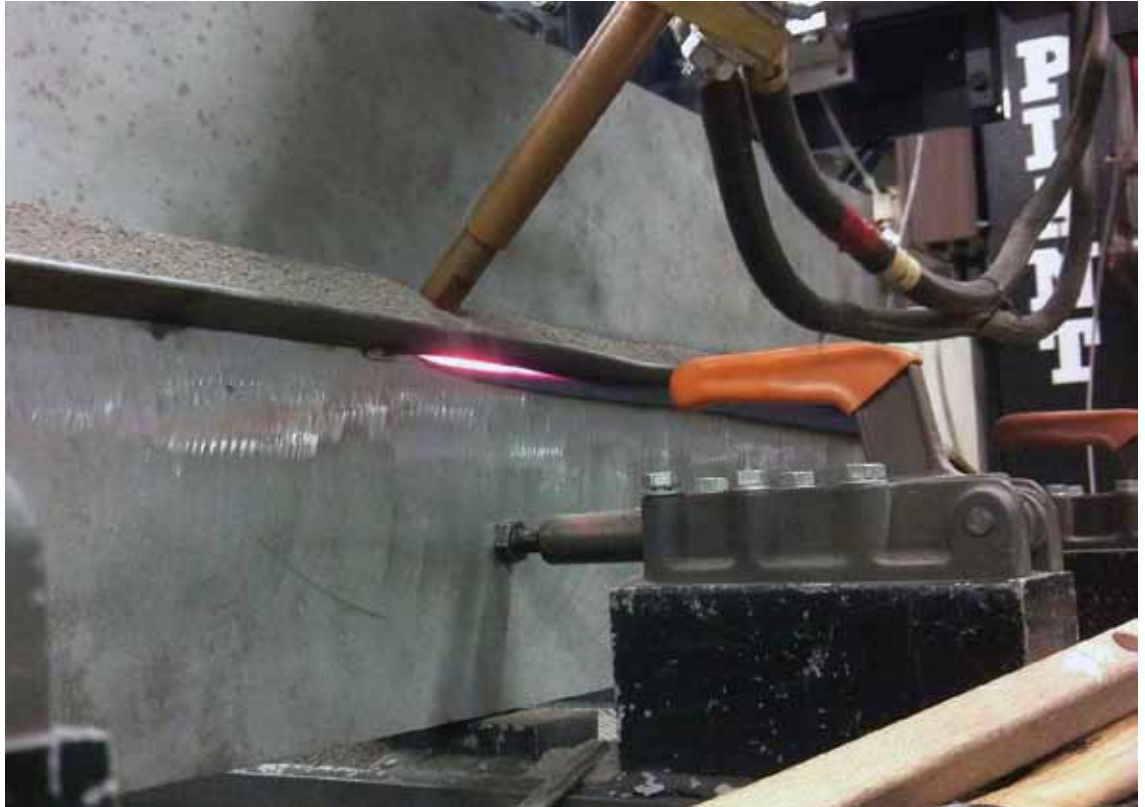


*Through the years, NMC has contributed significantly to cost reduction efforts for VCS. This report contains an overview of six projects employing various technologies to improve affordability of this ship class and other submarine classes. The PCU Missouri (SSN 780) is pictured. EB photo*



# DESIGN FOR MANUFACTURABILITY

*NMC uses a Design for Manufacturing and Assembly (DFMA) approach to weapon system fabrication challenges. Current projects employing a DFMA method are reducing cost and weight in the manufacture of DDG 1000 Advanced Gun Systems, and improving the manufacture of complex VCS weapons cradles and CVN 78 weapons and stores elevator doors.*



*Applying DFMA principles will reduce the cost and schedule of manufacturing VCS weapons cradles.  
NMC photo at Lincoln Electric*

The complex design of VCS weapons cradles, as well as the many design iterations through the years, has resulted in several issues that affect fit, form, and function. An NMC-led IPT is working to reduce the cost to manufacture VCS weapons cradles by improving the manufacturability of the cradle and/or its components. In Phase I of the project, the IPT applied Lean DFMA principles to the design and created a prioritized list of process and design for production recommendations and improvements. In Phase II, the team is validating those recommendations through analysis and fabrication of a prototype to support transition and implementation and to demonstrate the cost savings. This project is expected to reduce rejection rates and rework by approximately 10 percent. Cost reduction from reduced rework and improved DFMA recommendations are expected to result in \$612,000 to \$1.2 million savings per submarine hull, depending on improvements selected for validation. The IPT includes the VCS Program Office, Naval Undersea Warfare Center, Newport, EB, Newport News Shipbuilding (NNS), NSWCCD and NMC. The project recommendations will be implemented at EB and NNS beginning with SSN 784 for the Phase I results and SSN 788 in 2012–2013 for the remaining improvements.

NMC successfully reduced manufacturing cost and weight for the DDG 1000 Advanced Gun Systems (AGS) through various manufacturing improvements. The gun systems use the EX-813 AGS pallet to package, handle, store, and transport the Long-Range Land Attack Projectile munitions and charges through the Navy logistic channels and within the AGS magazine in the DDG 1000 hull. The project first provided a set of recommendations and accompanying technical data package of potential product manufacturing improvements. NMC then optimized the selected approaches, including improved gas tungsten arc welding joint design and welding techniques, along with advanced machining and casting of critical projectile and propellant assembly system parts. The various recommendations were demonstrated in a series of prototype sample builds. These improvements are scheduled to be incorporated into Low Rate Initial Production pallet systems beginning in 2012. The project achieved a 12 percent reduction in manufacturing cost, which equates to a \$6 million per hull savings, and a 190-pound-per-pallet reduction in system weight that will improve the safety and survivability of the AGS pallet



*Manufacturing process enhancements reduce the weight and cost of the AGS pallet without compromising system performance. NMC photo*

system. Program Executive Office, Integrated Warfare Systems' Naval Guns Program Office; Naval Surface Warfare Centers, Dahlgren and Port Hueneme Divisions; BAE Systems; and NMC contributed to this effort.

NMC recently completed work on similar issues with the new design of the CVN 78 Aircraft Carrier weapons and stores elevator doors. Thinner material and tight dimensional tolerances are resulting in extensive rework, and the large number of unique doors per ship is adding to the fabrication and

scheduling challenges. NMC and an IPT comprised of PEO Aircraft Carriers, NAVSEA 05, NSWCCD, Navy Joining Center and NNS, assessed improvements in several categories, including evaluating alternate materials and construction processes, optimizing current manufacturing processes, and implementing DFMA recommendations. The project results are expected to improve the cost, schedule, and quality of doors, which are manufactured at NNS. Follow-on project efforts will target improvements that can be demonstrated and validated to provide greater impact to CVN 79 and beyond.

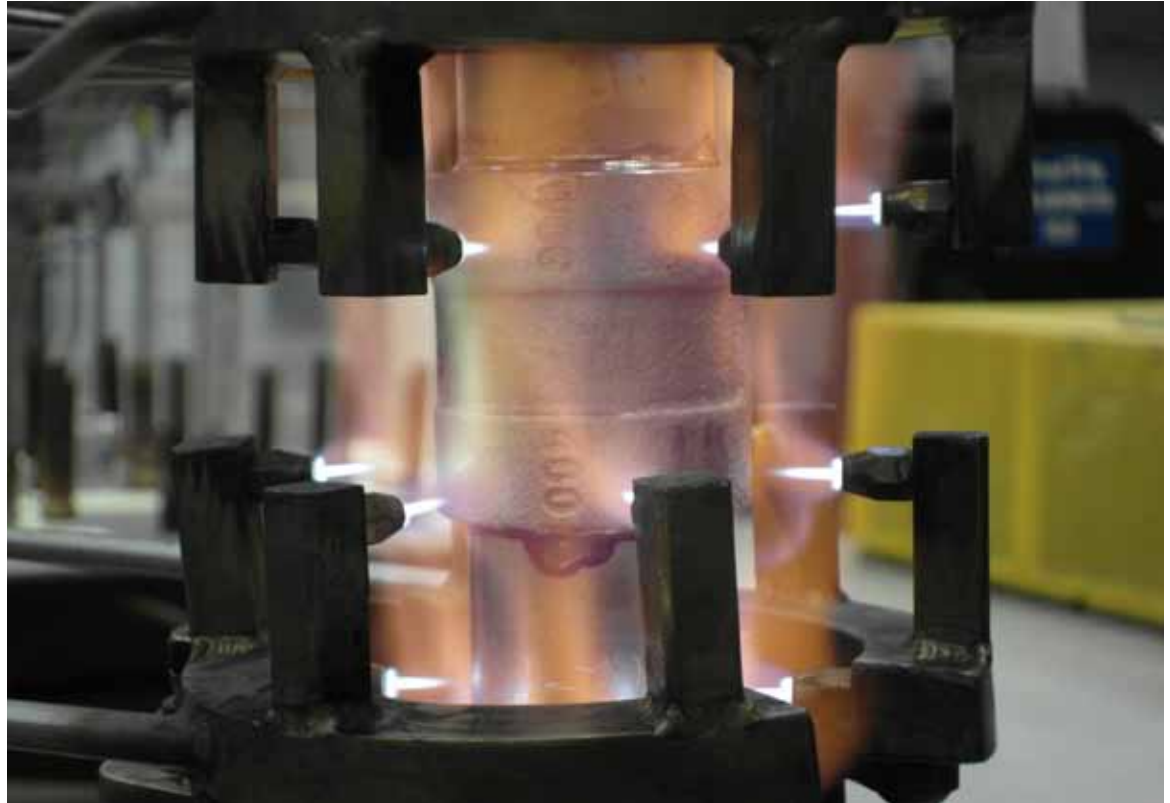


*NMC has achieved implementation success through several current and recent projects focused on DDG 1000 and DDG 51 ship classes, including the development of an automated back gouging tool estimated to save more than \$1 million for DDG 1000 (p. 11). USS Mitscher (DDG 57) is shown. U.S. Navy photo*



# JOINING TECHNOLOGIES

*A multitude of factors are considered when deciding the best method for joining metals – material, joint type, design and manufacturing requirements, and others. NMC is conducting several projects that are investigating alternative joining techniques that will save labor and manufacturing cost.*



*Brazing pipe joints shipboard with a small, lightweight heating system as opposed to the current method of torch brazing will reduce shipbuilding costs. NMC photo*

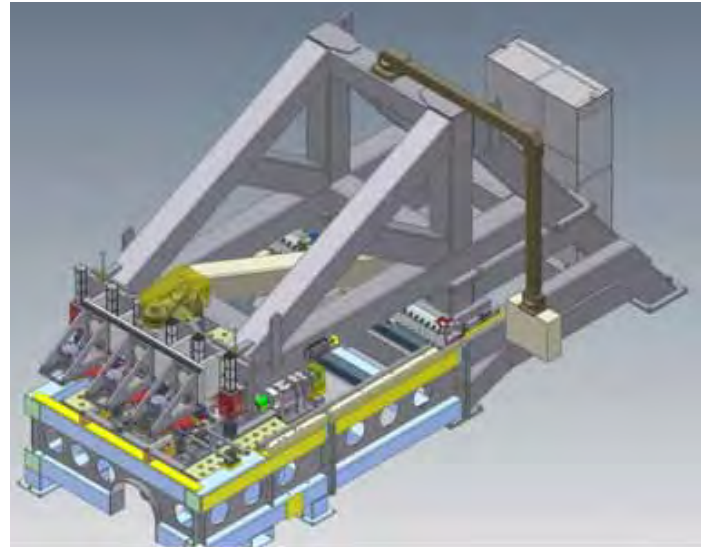
**A**n NMC project team developed a prototype flame brazing system that will solve a variety of issues associated with the current method used at NNS. The shipyard currently uses a hand-held torch to manually flame braze fittings shipboard. The process is labor intensive because of the time required to reach the melting temperature of the filler material. It also causes occasional paint damage because it is difficult to control the flame and to negotiate the minimal clearances that sometimes exist surrounding the fitting. The limited clearance also makes it difficult to manipulate the torch to achieve a uniform bond, which causes occasional pipe leaks. Paint damage and pipe leaks result in rework that further adds to the brazing cost. The IPT designed the prototype flame brazing system to address these problems for CVN and VCS construction. It uses a programmable logic controller, mass flow controllers, and a burner to surround the fitting. After successful testing, the prototype will be implemented into the CVN construction process at NNS by the end of January 2012. Implementing this alternative brazing technology will result in an estimated labor and production cost savings of \$2.3 million in the construction of three CVN and nine VCS new construction hulls, and the overhaul of six CVN hulls. In addition, the proposed solution may benefit other platforms requiring flame brazing. The CVN and VCS Program Offices, NSWCCD, NNS, Lean Engineering and NMC make up the IPT for this project.



Many cost and performance advantages are expected in another NMC project that is evaluating an alternative joining method, exothermic welding, for splicing large diameter copper conductors on aircraft carriers. Exothermic welding employs an exothermic reaction of a copper thermite composition to melt the copper-based weld metal to form a cable splice, requiring no external source of heat or current. This process can reduce the amount of labor required for installation, as well as subsequent preventive and corrective maintenance. The CVN Program Office supports the use of exothermic welding for shipboard power applications, but the effects of shipboard environmental conditions on weld quality are not fully understood, and Navy and shipbuilder experience with the process is very limited. This project is identifying applicable ship and system requirements for the Electromagnetic Aircraft Launch System (EMALS) power cables, as well as other applications on CVN 78 Class carriers, and determining via testing whether the proposed exothermic welding process identified for use during installation of the shipboard power cables meets system and shipboard performance requirements. Shipboard installation and repair procedures will be developed and approved for use. Additional life-cycle cost benefits associated with a more efficient multi-cable connection method are also expected. Other advantages include reduced risk to quality and schedule; increased system reliability and availability; and the creation of enhanced, repeatable, cost-effective installation and repair procedures. This project will potentially lead to a fleet-wide process for splicing power cables in high-current applications. NNS will utilize the NAVSEA-approved procedures to support installation of the EMALS on CVN 78 Class carriers in fiscal year 2013. The IPT includes the Future Aircraft Carrier Program Office, NSWCCD, NAVSEA 05, Naval Air System Command, NNS, and NMC.



*Utilizing exothermic welding for splicing large diameter power cables on CVN 78 is expected to reduce labor hours for installation, as well as preventive and corrective maintenance. NMC photo*



*An on-site low-cost friction stir welding machine would save costs and improve aluminum panel quality in the construction of the Joint High Speed Vessel. NMC image*

Friction stir welding (FSW) is a joining method that offers many benefits in ship construction. NMC is continuing its work with friction stir welding (FSW) in a project that would benefit the Joint High Speed Vessel (JHSV), whose ship design incorporates the use of large integrally stiffened aluminum panels produced via FSW. If panels are produced by off-site FSW vendors, the panel sizes are limited due to shipping constraints. On the other hand, assembling smaller panels via conventional welding methods at the shipyard is costly and frequently results in excessive distortion and other quality issues. Austal USA is seeking an on-site FSW capability to reduce cost and increase panel quality. A low-cost FSW system was developed and demonstrated for Freedom Class LCS applications during a previous NMC project. That machine design has been used as a baseline to develop a machine that will satisfy the product and process requirements for JHSV construction. This project will create a detailed design for an extended capabilities low-cost FSW machine, develop optimal processes and tooling for JHSV products, and assist in startup and training of the new system at Austal USA. Use of a low-cost FSW machine will enhance the producibility of lightweight aluminum structures on JHSV, which will reduce the cost of the ships, improve welded joint quality, and reduce vessel weight because there is no filler metal added to the weld as with traditional welding processes. Further, the technical advancements could be leveraged to other platforms with aluminum structures. In addition to Austal, the JHSV Program Office and NMC, the IPT includes ABS and Nova Tech Engineering.

While NMC has made many advances in alternative welding techniques, an NMC project team is looking at improving the process that is done before welding of certain ship components. Relaxing the time limit between cleaning and welding of aluminum-to-aluminum joints could lower fabrication cost on various Navy ships. Navy shipbuilders are required to remove contaminants on the joint and adjacent aluminum surfaces within eight to 16 hours prior to welding to mitigate weld contamination and to maintain weldment mechanical properties. If welding does not take place within the prescribed time limit, the weld surfaces require re-cleaning, which adds construction cost and time. An NMC project team, including NAVSEA 05P2 and NSWCCD, has analyzed the mechanical properties of the aluminum welds after different exposure times. This investigation may provide the data needed to relax the current time limit between cleaning and welding. The findings could lead to reduced construction costs by requiring the cleaning only of accessible surfaces instead of all adjoining surfaces immediately before welding when those surfaces have been exposed more than 16 hours prior to welding, as well as eliminating the need to break tack welds made between the initial cleaning and final welding. Furthermore, standardizing aluminum welding across several ship classes will reduce the administrative costs of maintaining multiple welding standards. Pending review by NAVSEA, the recommendations are expected to be implemented in early 2012 at Austal USA on the inspection plan for LCS 2 Class structural welds and, afterward, on LCS 4 and the Joint High Speed Vessel.



*Increasing the time allowed between cleaning and welding of aluminum joints may result in fewer reworked weld joints and lower fabrication costs on several Navy ship classes.*

*NSWCCD photo*

NMC is conducting a project that is evaluating alternative high-strength steel flux-cored arc welding (FCAW) electrodes to be approved as MIL-101TM electrodes for critical welding applications. The electrodes will be used for CVN 79 structural welds and other critical applications. MIL-101TM FCAW electrodes have historically exhibited inconsistent lot-to-lot notch impact toughness values in production-style test welds. NMC will evaluate candidate electrodes from leading producers and support the qualification testing required for NAVSEA approval. The major benefit will be the improved survivability of Navy combatant ships. In addition, several cost benefits could be realized, including cost avoidance, if notch toughness consistency is improved to avoid imposing shipyard testing requirements, estimated at \$1.4 million per hull, for the current MIL-101TM electrode. Further cost savings may be realized if the down-selected electrode(s) cost less than the baseline MIL-101TM electrode or reduces the need for costly weld preheat. The target weapon system is CVN 78 Class structural welds, but MIL-101TM is also used on other surface combatant ships. Pending NAVSEA approval of the improved FCAW electrode for ship construction, the electrode will be added to the Qualified Products List for use by NNS and other shipyards. NNS is anticipating use of the improved FCAW electrode in the construction of CVN 79 in 2014. In addition to NMC, the IPT includes the Future Aircraft Carrier Program Office, NNS, NSWCCD, and NAVSEA 05V3 and 05P24.



*NMC continues to advance a variety of manufacturing processes for the Navy's aircraft carriers. Shown is the USS George H.W. Bush (CVN 77), a ship in the Nimitz class. U.S. Navy photo*

# SHIPYARD PROCESSES

*While manual labor executed by skilled tradesmen will always be valuable in shipbuilding, introducing mechanized processes in some areas can add efficiencies in schedule and cost. NMC is leading several projects that are establishing innovative mechanized technologies in procedures that were once done by hand, as well as developing new techniques and designs to improve shipyard manufacturing processes.*



*An automated back gouging tool is increasing production rates and reducing labor costs for DDG 1000 construction.*  
BIW photo

## Prototype Mechanized Systems to Save Manual Labor

Building on the successful development of a mechanized weld shaver tool, an NMC-led IPT designed and built an automated back gouging tool for use at Bath Iron Works (BIW) in the production of the Peripheral Vertical Launch System and Anti-Propagation Wall components on DDG 1000. Currently, BIW manually arc gouges and grinds to produce the desired weld joint profile and quality. This labor-intensive process is slow, and the repetitive motion causes numerous injury claims. The weld shaver system was modified to perform back gouging for the DDG 1000 applications. Since implementing the back gouging tool in October 2010, BIW has estimated a labor savings of approximately \$400,000 on DDG 1000. The total cost savings for all DDG 1000 class ship production is estimated to be in excess of \$1M. In addition, if mechanized back gouging can be introduced at Ingalls Shipbuilding (Ingalls) for LHA, LPD, and NSC applications, an additional savings of approximately \$1.4 million may be realized. The IPT for this project included BIW, PushCorp, Inc., NMC, Ingalls and NSWCCD.





NMC is leading the development of another prototype tool that will reduce the need for manual labor. During ship construction, rust and primer must be removed from the weld joint areas of large steel plates to be welded. That edge preparation is done manually in a slow and labor-intensive process. NMC is leading a project that is developing a prototype tool to minimize the amount of manual grinding on these large plates. A mechanized system will have a significant impact on construction since there are several thousand plates per ship, with several edges per plate requiring preparation. Specifically, the system is expected to increase the production rate by 25 percent and save \$2.5 million per DDG 1000 Class hull. In addition, the technology has the potential to reduce shipyard injury claims by 50 percent. The IPT evaluated commercially available surface preparation and manipulation technologies that may be integrated into a prototype



*For the construction of DDG 1000, a prototype system is being developed that will minimize manual grinding of plate edges for weld preparation, which is slow and physically taxing work. NMC photo*

system, solicited industry for concepts, as well as created its own system designs. The first Navy ship to apply this technology will be DDG 1000, which is being constructed at BIW. After DDG 1000 implementation, other weapon systems could benefit from this technology. The DDG 1000 Program Office, NSWCCD, BIW, and Ingalls are contributing to this effort.

NMC recently completed a project that developed several automation methods for specific areas of pipe preparation in VCS construction. Improved processing methods for welding large diameter pipe (3"-12" diameters) are expected to save significant manual labor and construction costs. VCS off-hull new construction pipe welding consist of complex configurations of large diameter pipe that require detailed preparation, fixturing, positioning, fit-up, and welding methods. Current fabrication techniques and weld processes require excessive labor in set-up and handling times, reducing work cell process flow output and



*Improved processing methods, including the use of this pipe purging tool, for welding large diameter pipe are expected to save significant manual labor and construction costs for VCS. NMC photo*

efficiencies. NMC's work focused on fixturing, positioning, and fitting; pipe boss methods; enhanced welding; as well as the use of internal pipe joint blending tools. These improvements will reduce pipe section cutting, rework, and pipe material scrap. Projected savings are estimated to be 8,500 man-hours per hull in manual labor and a projected \$5.5 million savings over the next 10 VCS planned hulls in the FY13-FY17 year period. Prototype process improvements were tested and validated in both EB and NNS pipe shops. Full implementation is planned in both VCS pipe shops for SSN 788 in third quarter FY12. In addition to the shipyards, the IPT included the VCS Program Office, NSWCCD, and NMC.

## Addressing Thermal Issues in Welding

NMC is generating a prototype system that will demonstrate the capability to control the preheating of welding assemblies prior to welding in a production environment. Currently, an operator manually controls the temperature by using percentage timers or by plugging/unplugging the power cord and monitors the temperature by using "temp sticks" at each weld



*A system that remotely controls preheating of weld assemblies, as opposed to manually controlling the temperatures with heater bars, will reduce costs and rework associated with overheating. The alpha prototype is shown above. NMC photo*

station to determine base metal temperature. With the current system, the assembly is susceptible to overheating, causing damage to non-metallic materials within the weld assembly. Rework associated with cleaning and re-applying non-metallic material and addressing damaged assemblies can cause significant additional cost and schedule delays. This system could reduce the cost associated with manually controlling welding preheat temperatures as well as diminish the risk of damage to weld assemblies containing non-metallic materials. Specifically, full implementation can result in a cost savings of approximately \$740,000 per hull. After implementation, the system would support other Navy weapon system applications involving less heat-sensitive, but manually controlled, processes for pre-heated metals. The IPT includes the Future Aircraft Carrier Program Office, NSWCCD, NNS, EB, and NMC.



*Cooling-assisted welding will prevent coating damage on the back side of plates and tank walls. NMC photo*

The heat involved in small welds made in the latter stages of ship construction can damage the coating that has already been applied to the back side of the surface. NMC developed solutions to remove much of the heat effects caused by welding, which will maintain the surface temperature below the level that causes coating damage. Typically, small hanger and stud welds can damage the coating on the back side of the structure. The welding-induced heat can cause coating discoloration, delamination, and smoking. In some cases, the damage is not readily observable, but the damaged coating can fail prematurely. To preclude this damage,

the coating is often removed from the back side of the structure prior to welding and is reapplied after welding. The labor to repair these damaged coatings in certain locations can be extensive. The IPT, which consisted of Future Aircraft Carrier Program Office, NNS, NSWCCD, and NMC, identified the effects of typical welding processes on usual attachment and wall thickness combinations

with standard Navy coating systems. This project also designed and tested several cooling techniques that will prevent the welding-induced damage to coatings for many of these attachment and wall thickness combinations. NNS will perform detailed investigations to confirm the project test results in the shipyard environment using their welding equipment and will develop technical notes to augment its standard welding processes. Recommendations from this project may result in a 20 percent reduction in coating rework labor. Cost savings projections will be developed after the technical notes are reviewed with NNS welding and coating trades management to determine the best labor utilization for implementation on CVN 78 Class ships. The cooling techniques will also benefit other ship classes.

## Prototype Systems to Improve Inspection Processes

An NMC project is underway that will improve the accuracy of inspections of special hull treatment (SHT) through the use of an impulse hammer system. SHT must be sufficiently adhered to the ship's hull to permit longevity of the system and to ensure peak functional performance while in service. To ensure proper adhesion, quality inspections are conducted by manually tapping the SHT using a hammer, which is very subjective to the inspector performing the inspection. An NMC-led IPT is investigating the use of impulse hammers, which mimics the current inspection method, but the input force and response are measured electronically instead of using human senses. Identifying and correcting a debonded SHT area during VCS construction is significantly less costly than correcting the problem after delivery of the ship, since the processing equipment, staging and environmental controls are already in place. A cost avoidance of \$348,000 per hull may be realized by repairing SHT debonds during construction as opposed to after delivery. Implementation is planned for November 2012 at EB for SSN 786. The IPT for this effort includes the VCS Program Office, NSWCCD, EB, NAVSEA 04X, and NMC.



*Using impulse hammers to identify debonded special hull treatment areas during VCS construction will save significant costs rather than correcting the problem after delivery. NDTnet photo*





*NMC is developing a white light scanning system for inspecting tapers of main propulsion shafts. The project is expected to save ship construction and maintenance costs. NMC photo*

Inspecting the tapers of main propulsion shafts for submarines and aircraft carriers involves heavy and cumbersome gauges. An NMC project team is developing a white light scanning system that would replace those gauges and save significant costs. Power is applied to submarine and aircraft carrier main propulsion shafts through a tapered connection between the shaft and the inboard coupling. Each taper requires from six to 10 inspections as the taper is carefully shaped to the correct contour. NMC is leading an effort to create a prototype system that will eliminate the labor-intensive, costly, single-purpose gauges that are used to perform blue contact checks. The IPT solicited industry for a white light scanning system and selected a vendor to work with to create a prototype for shipyard use and to optimize the prototype in response to testing and evaluation. Norfolk Naval Shipyard is expected to implement the technology in August 2012; the other three naval shipyards and the shaft manufacturing facilities plan to implement it after that. The four naval shipyards can expect to see a cost savings of \$10.8 million over five years based on eliminating the maintenance on the 36 gauges currently in the system by replacing them with four white light scanning systems, eliminating the need to purchase eight gauges for VCS, and reducing the labor to perform shaft inspections by 7,400 hours annually. In addition to cost benefits, safety during taper measurements will be enhanced by removing the need for lifts and the necessity to work near suspended loads, and taper measurement accuracy will be improved by removing the variation that is inherent to blue checks. In addition to NMC and the shipyards, the project team includes NAVSEA 05Z22, NAVSEA 04X, NSWCCD, and Steinbichler Vision Systems.

## Alternative Design to Reduce Labor and Material Costs

NMC is investigating an alternative design to the temporary padeyes used during submarine overhauls in an effort to reduce labor and material costs. The current padeye is fillet welded and requires 160 man-hours of labor to install and then remove. The leading alternate candidate is a swivel hoist ring mounted on a threaded HY-80 stud. Project work includes developing optimized stud welding parameters and selecting the correct swivel hoist rings. The stud-mounted swivel hoist rings are being tested to demonstrate that they consistently meet lifting and handling requirements. This project will also identify and determine the effects of any errors that might be made during installation. An estimated \$235,000 cost avoidance per overhaul could be realized from reducing the labor associated with installing and removing padeyes. Although the largest part of the cost savings is from reducing the welding labor, there are also significant savings in minimizing the effects of installation and removal on the SHT and internal hull insulation. Over a five-year period, the estimated cost avoidance is approximately \$2.4 million. Although, the results of this project will be applicable to all submarine classes, the majority of the savings will be realized during overhauls of Los Angeles Class submarines. The solution will be implemented at Portsmouth Naval Shipyard in June 2012 for the overhaul of the USS TOPEKA (SSN 754). The other three naval shipyards are also expected to implement the results. In addition to the naval shipyards, the IPT includes NAVSEA 04X and NMC.



*An alternative design to the temporary padeyes used during submarine overhauls will reduce labor and material costs. NMC photo*



# COATINGS APPLICATION AND REMOVAL

*NMC has led projects addressing surface treatment of weapon systems, including coating materials, application and removal, which can significantly impact performance, life cycle and cost. Recent coatings work involve investigating laser technology, improving grit blasting, and alternative temporary coating materials.*



*VCS is the backbone of the Navy's attack submarine force and one of three classes of nuclear-powered submarines in service. Current NMC efforts are designed to help the Navy achieve its build plan of two VCS per year. Pictured is the USS Hawaii (VCS). U.S. Navy photo*

**G**rit blasting is the most common method of surface preparation prior to coating application in shipbuilding, but there are opportunities to make grit blasting and associated processes more efficient. An NMC project is conducting a series of trials to optimize the grit blasting parameters. These trials are leveraging the results of previous studies and include various combinations of parameters, including variations of blast media type, blast media size, nozzle angle, and nozzle type. Shipyard procedures require that piping systems be protected when blasting nearby surfaces, and the IPT, which consists of the VCS Program Office, NSWCCD, EB, NNS, and NMC, is looking at this process as well. The current practice is to wrap the piping, blast the surface,



*By improving the abrasive blasting process for structural steel on VCS, as well as the wrapping of piping similar to that shown in this mockup, the amount of construction labor needed will be reduced. NMC photo*

remove the wrapping, clean the piping, and rewrap the piping prior to painting. The results of this project are expected to save approximately \$350,000 per VCS hull in reduced labor, materials, and disposal cost. The majority of these savings are the result of reducing the labor associated with wrapping pipes prior to blasting in a tank. Initial implementation is expected to take place at EB and NNS for SSN 787 in 2012. Project results will also apply to almost all ship classes.

laser technology for removing coatings from submarine propulsion shafts at Portsmouth Naval Shipyard (PNS). The IPT, which included PNS, NAVSEA 04X, NAVSEA 05Z22, and NMC, developed laser ablation processes using a variety of laser systems and evaluated the effects of those processes on shaft steel. While the shipyard was able to pursue an alternate solution to this issue, NMC will use the information gathered in this project to pursue other applications with the naval shipyards.

Both NNS and Ingalls have similar needs for temporary coatings to protect certain CVN and DDG 51 components during construction. An NMC project is indentifying temporary coatings that will prevent or reduce damage and corrosion that occurs during the shipbuilding process, significantly reducing the labor currently needed to remove the corrosion or repair damage. The IPT is investigating, modifying, and demonstrating temporary coatings/materials that can be easily applied and removed. Commercially available materials used in other industries may be used or adapted to meet established technical and cost-reduction goals. Implementing a temporary coating to protect an estimated 300,000 linear feet of exposed weld joint area on CVN 79 modules at NNS has the potential to save \$1 million to \$1.5 million per hull as a result of 50-70 percent reduction in labor and material costs for the temporary coating. Implementing a temporary coating to protect non-skid during the construction of DDG 51 at Ingalls has the potential to save \$150,000 per hull on non-skid repair due to damage and staining on previous hulls. Results of this effort may also apply to LPD, LHA, CVN, and other vessels. Implementation is expected to occur on some CVN 79 modules in FY12; future DDG 51 Class vessels, DDG 113 and DDG 114; and LHA 6. The IPT for this project includes the two shipyards, the Future Aircraft Carrier Program Office, NSWCCD, and NMC.



*An NMC project team investigated laser processes as an alternative to grit blasting to prepare surfaces for coatings. NMC photo*

While grit blasting is the usual process to prepare surfaces for coatings, using that method on submarine propulsion shafts requires moving the shafts from the machine shops to another location within the repair yards, adding extensive time and cost. NMC has completed work on a project designed to replace grit blasting with operations that could be performed in the machine shops, which would eliminate the extensive time and cost associated with moving submarine propulsion shafts within repair yards. The project investigated



## Projects Included in this Report:

### **Metalworking Technologies**

S2279 Waterjet Inlet Tunnel (WjIT) Manufacturing Improvement

S2304 Development of Long Length, Flexible, Vacuum-Jacketed Cryostats

### **Advanced Metallic Materials**

S2341 Reduced Cost Lightweight Uptakes for LCS

S2263 Development of 15-5PH Forgings for Torpedo Muzzle Door Lever Arms

S2368 Improved Shaft Cladding Materials and Processes

### **Design for Manufacturability**

S2319 Weapons Cradle Manufacturing Cost Reduction

S2132-2 Low Cost Pallet Systems – Phase II

R2448 Weapons and Stores Elevator Door Improvements

### **Joining Technologies**

S2298 Alternative Brazing for Shipboard Use

S2330 Exothermic Welding for CVN

S2321 Extended Capabilities for Low Cost Friction Stir Welding

R2445 Extended Delay Between Cleaning and Welding of Aluminum

S2372 FCAW Electrodes with Improved Toughness

### **Shipyard Processes**

R2335 Automated Back Gouging of Thick Plate

S2373 Plate Edge Preparation Improvements

S2326 Large Diameter Pipe Process Improvements

S2291 Remote Welding Preheat Control System

S2356 Prevention of Coating Damage During Hot Work

S2363 SHT Debond Detector

S2365 Main Propulsion Shaft Taper Inspection

R2457 Alternative to Temporary Padeyes

### **Coatings Application and Removal**

S2338 Optimization of Blasting Operations

S2320 Submarine Shaft Coating Removal

S2331 Temporary Protective Coatings





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